

FIELD

[0001] The invention is related to closed-case removable expansion cards for computer hosts, such cards having particular application to portable computer hosts such as handheld computing devices.

BACKGROUND

[0002] The broad use of portable host computers, including Personal Digital Assistants (PDAs), has been severely hampered by limited capabilities for expansion or customization. Expansion and application customization has been performed via only one, or at most two, slots for removable expansion cards for I/O, I/O adapters, memories, and memory adapters. Memory expansion cards have included DRAM, SRAM, ROM, and Flash technologies. I/O expansion cards have included dedicated peripherals, networking, modems, wireless communications, serial I/O, and bar-code and other scanners.

[0003] Having only one slot meant choosing between memory or peripheral expansion. In two-slot implementations, one of the slots is generally used for peripheral expansion, and the other for memory expansion. As market forces and consumer demand are pushing future PDAs to be ever smaller, allocating packaging volume for two-slots will be increasingly viewed as a costly and nonviable solution.

1 Memory and Expansion Card Standards

2 **[0004]** Two of the most popular industry standards for the
3 slots and removable cards are the PC Card and the CompactFlash
4 Card. The PC Card has a 16-bit variant, previously known as a
5 PCMCIA card, and a newer 32-bit variant, also known as a Card-
6 Bus card. U.S. Patent 5,815,426 ('426), ADAPTER FOR
7 INTERFACING AN INSERTABLE/REMOVABLE DIGITAL MEMORY APPARATUS
8 TO A HOST DATA PART, assigned to Nexcom Technology, and hereby
9 incorporated by reference, describes these and other removable
10 expansion card and memory types suitable for PDAs. In
11 addition to the PC Card and CompactFlash Card formats, the
12 '426 patent includes discussions of and references to
13 Miniature Cards, Solid State Floppy Disk Cards (SSFDCs),
14 MultiMediaCards (MMC), Integrated Circuit (IC) Cards (also
15 known as Smart Cards), and Subscriber Identification Module
16 (SIM) Cards.

17
18 CompactFlash Card

19 **[0005]** Figures 1A, 1B, and 1C are different views of a
20 prior art Type II CompactFlash Card. The CompactFlash
21 physical, electrical, and software interface architecture is
22 taught in the CompactFlash Specification Revision 1.3,
23 Copyright 1998, by the CompactFlash Association, P.O. Box
24 51537, Palo Alto, CA 94303, which is hereby incorporated by
25 reference. Figures 1A, 1B, 1C, part of 6A, and part of 6B are
26 reproduced or derived from the CompactFlash Specification
27 document.

1 **[0006]** U.S. Patent 5,887,145 ('145), REMOVABLE
2 MOTHER/DAUGHTER PERIPHERAL CARD, assigned to SanDisk
3 Corporation, and hereby incorporated by reference, describes
4 the required features of host systems for CompactFlash Cards,
5 including controllers required by CompactFlash memory cards
6 (CF cards) and comprehensive controllers required by
7 CompactFlash memory and I/O cards (CF+ cards).
8

9 MultiMediaCard

10 **[0007]** Figure 2A and 2B represent a prior art
11 MultiMediaCard form factor and its pad definitions. Figure 3A
12 and 3B represent the prior art internal architecture of a
13 generic MultiMediaCard and its registers. Figure 4A
14 illustrates the prior art functional partitioning of a generic
15 MultiMediaCard system. Figure 5 illustrates the prior art
16 physical partitioning of a generic MultiMediaCard system.
17

18 **[0008]** The MMC and MMC related system issues are taught in
19 the MultimediaCard System Summary Version 2.0, Copyright
20 January 1999, by the MultiMediaCard Association, 19672 Stevens
21 Creek Blvd., #404, Cupertino, CA 95014-2465, which is hereby
22 incorporated by reference. Figures 2A, 2B, 3A, 3B, 4, 5, and
23 part of 6A are reproduced or derived from the MultimediaCard
24 System Summary document.
25

26 **[0009]** Figure 6A and 6B are different views comparing the
27 form factors of the prior art CompactFlash Card (top) and
28 MultiMediaCard (bottom). In each of 6A and 6B, the

1 CompactFlash Card and the MultiMediaCard are both roughly to
2 equal scale.

3
4 Adapters for Removable Memories

5 **[0010]** Adapters exist or have been prophetically disclosed
6 for physically and electrically coupling a removable memory on
7 a slide, or stick, to a portable host via a removable
8 expansion card of either the PCMCIA Card or CompactFlash Card
9 form factors. The previously mentioned '426 patent describes
10 such removable memory adapters. The focus of these existing
11 memory adapters has been limited to merely providing an
12 interface adapter, or bridge, between a first interface type
13 (the host to removable-expansion-card interface) and a second
14 interface type (the removable memory stick).

15
16 PC Card Mother and CompactFlash Card Daughter Combinations

17 **[0011]** Adapters exist or have been prophetically disclosed
18 that comprise a special mother PC Card designed to accept one
19 or more daughter CompactFlash Cards of one or more types. The
20 previously '145 patent describes such CompactFlash adapters.
21 The focus of these existing mother/daughter combinations has
22 also been limited. First, the daughters have been used for
23 memory expansion for the host platform, primarily in the form
24 of flash-memory-based mass-storage-like devices. In this
25 first approach, the mother card provides the requisite mass-
26 storage controller functionality. Second, the daughters have
27 been used for dedicated peripheral, I/O, or communication
28 functions. In this second approach, the mother card has a so-
29 called comprehensive controller that augments the mass-storage

1 controller functionality with functions commonly required or
2 useful to multiple daughter cards. Third, in a variation of
3 either of the first two paradigms, functions of the general-
4 purpose host may be relocated to the mother card.

5

6 Background for PC-Card Based I/O Functions

7 **[0012]** Techniques are known in the art for making and using
8 systems that perform such I/O functions in a PC card. For
9 example, see U.S. Patent 5,671,374 ('374), PCMCIA INTERFACE
10 CARD COUPLING INPUT DEVICES SUCH AS BARCODE SCANNING ENGINES
11 TO PERSONAL DIGITAL ASSISTANTS AND PALMTOP COMPUTERS, assigned
12 to TPS Electronics, which is hereby incorporated by reference.
13 The '374 patent teaches the use of PDAs and similar hosts
14 equipped with PC card interfaces for I/O devices including
15 portable laser-scanners, magnetic stripe and ink readers,
16 keyboards and keypads, OCR devices, and trackballs.

17

18 **[0013]** Techniques are also known in the art for making and
19 using PC Card-based radios for applications based in a
20 portable host. For example, see U.S. Patent 5,519,577 ('577),
21 SPREAD SPECTRUM RADIO INCORPORATED IN A PCMCIA TYPE II CARD
22 HOLDER, assigned to Symbol Technologies, and hereby
23 incorporated by reference.

24

25 **[0014]** Techniques are also known in the art for making and
26 using disk emulation devices based on flash memory. For
27 example, see U.S. Patent 5,291,584 ('584), METHODS AND
28 APPARATUS FOR HARD DISK EMULATION, assigned to Nexcom
29 Technology, and hereby incorporated by reference.

1 Background for Relevant Application Specific Functions

2 **[0015]** Techniques are known in the art for making and using
3 systems that download or capture compressed digital audio for
4 storage and later playback using dedicated removable media.
5 For example, U.S. Patent 5,676,734 ('734), SYSTEM FOR
6 TRANSMITTING DESIRED DIGITAL VIDEO OR AUDIO SIGNALS, assigned
7 to Parsec Sight/Sound, and hereby incorporated by reference,
8 teaches a system for transmitting digital video or audio
9 signals over a telecommunications link from a first to a
10 second party. In addition, U.S. Patent 5,579,430 ('430),
11 DIGITAL ENCODING PROCESS, assigned to Fraunhofer Gesellschaft
12 zur Foerderung der angewandten Forschung e.V., and hereby
13 incorporated by reference, teaches processes for encoding
14 digitized analog signals. Such processes are useful for
15 insuring high-quality reproduction while reducing transmission
16 bandwidth and data storage requirements.

17
18 **[0016]** Techniques are also known in the art for making and
19 using record and playback portable host devices based on a
20 dedicated flash memory. For example, see U.S. Patent
21 5,491,774 ('774), HANDHELD RECORD AND PLAYBACK DEVICE WITH
22 FLASH MEMORY, assigned to Comp General Corporation, and hereby
23 incorporated by reference, and U.S. Patent 5,839,108 ('108),
24 FLASH MEMORY FILE SYSTEM IN A HANDHELD RECORD AND PLAYBACK
25 DEVICE, assigned to Norris Communications, also hereby
26 incorporated by reference.

27

1 Limitations of Previous Approaches

2 **[0017]** In general purpose portable hosts, populating an
3 expansion slot has meant choosing one of either removable
4 memory or peripheral expansion for that slot. When used for
5 memory expansion, the removable memory has been limited to use
6 for the system or application software running on the host.
7 In essence, the removable memory has only been used as host-
8 dedicated memory. This was done either directly, e.g., as
9 some portion of the main-memory of the host, or indirectly as
10 an emulation substitute for host mass-storage (i.e., disk
11 drives).

12

13 **[0018]** When used for I/O expansion, the expansion I/O-cards
14 have not had access to a private removable media/memory. This
15 has prevented portable computer hosts, such as PDAs, from
16 being used as a customizable platform for many application-
17 specific functions that require a removable memory dedicated
18 to the application.

19

20

21 SUMMARY

22

23 **[0019]** The utility of portable computer hosts, such as
24 PDAs, is enhanced by methods and apparatus for closed-case
25 removable expansion cards having a removable memory in both a
26 first and second embodiment. In both the first and second
27 embodiments the closed-case removable expansion cards
28 preferably use a Type II CompactFlash form factor. In the
29 first embodiment the removable memory is in combination with

1 an external-I/O connector or permanently attached external-I/O
2 device, providing both I/O and memory functions in a single
3 closed-case removable expansion card. This increases the
4 expansion functional density for portable computer hosts, such
5 as PDAs. That is, it increases the amount of functionality
6 that can be accommodated within a given volume allocation for
7 expansion devices. It also provides a viable alternative to
8 2-slot implementations.

9
10 **[0020]** In the second embodiment the removable memory is a
11 private memory for application specific circuitry within the
12 closed-case-removable expansion card. This enhances the
13 utility of portable computer hosts, such as PDAs, as universal
14 chassis for application specific uses. The standard
15 CompactFlash physical and electrical interface couples the
16 application specific card to the host, which provides user
17 interface functions for the application. The cards include a
18 top located slot and an internal connector for accepting a
19 MultiMediaCard as the private removable memory. In addition,
20 the application specific card will generally have some manner
21 of I/O to required external devices, such as scanning devices,
22 sensors, or transducers. Otherwise, all functionality for the
23 application specific function is self-contained within the
24 application specific card.

25
26 **[0021]** Particular application specific cards for
27 customizing general purpose PDAs via the instant invention
28 include a media-player card for digitized media stored on

1 removable memory and a bar-code-scanner card having scanning
2 data stored on removable memory.

3
4
5 BRIEF DESCRIPTION OF DRAWINGS

6
7 **[0022]** Figures 1A, 1B, and 1C are different views of a
8 prior art Type II CompactFlash card.

9
10 **[0023]** Figure 2A and 2B represent a prior art
11 MultiMediaCard form factor and its pad definitions.

12
13 **[0024]** Figure 3A and 3B represent the prior art internal
14 architecture of a generic MultiMediaCard and its registers.

15
16 **[0025]** Figure 4A illustrates the prior art functional
17 partitioning of a generic MultiMediaCard system.

18
19 **[0026]** Figure 5 illustrates the prior art physical
20 partitioning of a generic MultiMediaCard system.

21
22 **[0027]** Figure 6A and 6B compares the form factors of the
23 prior art CompactFlash card (top) and MultiMediaCard (bottom).

24
25 **[0028]** Figure 7 illustrates a PDA equipped with a removable
26 expansion card having both I/O and removable memory in
27 accordance with the present invention.

1 **[0029]** Figure 8 illustrates some of the various types of
2 I/O for which the PDA and removable expansion card of Figure 7
3 may be equipped.

4
5 **[0030]** Figure 9 is an abstract drawing representing the
6 removable expansion card of Figure 7 separate from the PDA,
7 and with the I/O and memory disengaged from the removable
8 expansion card.

9
10 **[0031]** Figure 10 is an abstract drawing representing the
11 construction detail of the upper and lower frame of the
12 removable expansion card of Figure 7.

13
14 **[0032]** Figure 11 is an abstract drawing representing an
15 exploded view of the removable expansion card of Figure 7,
16 including the outer frame, inner PCB, and connectors.

17
18 **[0033]** Figure 12A is an abstract drawing representing a
19 view of the removable expansion card of Figure 7, with the
20 outer frame removed, and a removable memory roughly aligned
21 with the contact fingers to which it mates within the
22 removable expansion card.

23
24 **[0034]** Figure 12B is an abstract drawing representing a cut
25 away side view of the removable expansion card of Figure 7,
26 with the removable memory inserted into the removable
27 expansion card.

1 **[0035]** Figure 13A is an abstract drawing representing an
2 end view silhouette of the removable expansion card of Figure
3 7.

4
5 **[0036]** Figure 13B is an abstract drawing representing a
6 cross-sectional view silhouette of the upper frame member of
7 the removable expansion card of Figure 7.

8
9
10 DETAILED DESCRIPTION

11
12 Components of the Expansion Card

13 **[0037]** Figure 9 is an abstract drawing representing a
14 closed-case removable expansion card **100**, i.e., an expansion
15 card that may be inserted into and removed out of a closed-
16 case computer host. The card is especially suitable for use
17 in a portable host, such as a PDA. In accordance with the
18 present invention, the expansion card of Figure 9 includes a
19 connector **141** for I/O interconnect and a slot **121** for a
20 removable memory. Figure 9 shows the I/O interconnect **140** and
21 removable memory **120** disengaged from the removable expansion
22 card.

23
24 **[0038]** Figure 10 is an abstract drawing representing the
25 construction detail of the upper **105** and lower **110** frame
26 members of the removable expansion card **100** of Figure 9. An
27 opening **111** is provided in the lower frame **110** for receiving
28 the connector **141** for I/O interconnect.

1 **[0039]** Figure 11 is an abstract drawing representing an
2 exploded view of the removable expansion card **100** of Figure 9,
3 including the outer frame, inner PCB **115**, and connectors.
4 Visible for the first time in the view of Figure 11, a second
5 opening **113** is provided in the lower frame **110** for receiving
6 the connector **150** for host interconnect. Additionally, a slot
7 **112** is provided on both sides of the opening **111** to aid in the
8 alignment and retention of the connector **141**, and a slot **114**
9 is provided on both sides of opening **113** to aid in the
10 alignment and retention of the connector **150**. An opening **116**
11 is provided in the PCB for receiving the connector **141**.

12

13 **[0040]** Figure 12A is an abstract drawing representing a
14 view of the removable expansion card **100** of Figure 9, with the
15 outer frame members removed, and a removable memory **120**
16 roughly aligned with the contact fingers **180** to which it mates
17 within the removable expansion card. Circuitry **160** is
18 provided, including I/O adapter circuitry, removable memory
19 adapter circuitry, and application-specific circuitry. A
20 support shelf **170** supports, aligns, separates, and isolates
21 the underside of the contact fingers **180** from the circuitry
22 **160**.

23

24 **[0041]** Figure 12B is an abstract drawing representing a cut
25 away side view of the removable expansion card **100** of Figure
26 9, with the removable memory **120** inserted into the removable
27 expansion card.

28

1 **[0042]** Figure 13A is an abstract drawing representing an
2 end view silhouette of the removable expansion card **100** of
3 Figure 9. Figure 13B is an abstract drawing representing a
4 cross-sectional view silhouette of the upper frame member 105
5 of the removable expansion card 100 of Figure 9. Guides **190**
6 provide alignment and support for removable memory inserted
7 via slot **121**.

8
9 **[0043]** In a preferred embodiment, the expansion card **100**
10 and associated host connector **150** are compatible with the Type
11 II CompactFlash Card as described in the previously referenced
12 CompactFlash Specification. The I/O connector **141** is
13 compatible with a PC-Card industry standard Honda-style 15-pin
14 connector. The slot **121**, removable memory **120**, and removable
15 memory adapter circuitry of circuitry **160**, are compatible with
16 the MultiMediaCard as described in the previously referenced
17 MultiMediaCard System Summary.

18
19 Circuitry on the Expansion Card

20 **[0044]** In a first embodiment of the invention, circuitry
21 **160** includes I/O adapter circuitry and removable memory
22 adapter circuitry. The I/O adapter functionality may include
23 one or more of, but is not limited to, Ethernet, serial port,
24 audio, telephone, antenna, and special-function interfaces
25 such as bar code and other scanners. The removable memory
26 adapter functionality may include one or more of, but is not
27 limited to, main memory expansion, mass-media emulation, and
28 other host-based special-purpose memory applications.

1 **[0045]** In accordance with a second embodiment, circuitry
2 **160** further includes application-specific circuitry for which
3 the management of the removable memory is an ancillary
4 function to the primary function of the specific application.
5 Specific examples of such application-specific expansion cards
6 having both I/O and removable memory are provided in later
7 sections.

8
9 **[0046]** In preferred implementations of both of the first
10 and second embodiments mentioned above, the functions
11 performed by the removable memory are those of a
12 MultiMediaCard adapter as illustrated in the MultiMediaCard
13 adapter section of the MultiMediaCard system architecture
14 diagram of Figure 4. If the removable memory is being used to
15 provide host-base memory expansion, such as described for the
16 first embodiment, then the host must provide the functionality
17 illustrated by the Application and Application Adapter
18 sections of Figure 4. If the removable memory is being used
19 at least sometimes as an ancillary memory (at least sometimes
20 private) to the application-specific circuitry contained on
21 the expansion card, such as for the second embodiment, then
22 the application-specific circuitry must provide the
23 Application and Application Adapter section functionality, or
24 else the application-specific circuitry must call on host
25 services for such functionality.

26
27 **[0047]** Examples of known techniques for making and using
28 other types of memory adapter circuitry for closed-case
29 expansion cards or with flash memory are found in the

1 previously referenced '145, '426, '584, '774, and '108
2 patents, among others. Examples of known techniques for
3 making and using I/O adapter and application-specific
4 circuitry for functions implemented in closed-case expansion
5 cards and with flash memory are found in the previously
6 referenced '374, '577, '774, and '108 patents, among others.

8 Frame Kit Assembly

9 **[0048]** The top and bottom frames may be composed of metal
10 or plastic. In a preferred embodiment, the top and bottom
11 frame portions each have a plastic base augmented with an
12 outer metal plate over much of the interior region of the
13 large panel surface of each portion. The metal plate extends
14 to the edges of the panel at the connector ends of each
15 portion and is attached to both connectors. In addition,
16 smaller metal strips, or ears, on both sides at the finger-
17 grip end (opposite to the host connector) extend from the
18 plate to the edges of the panel and continue onto the sides.
19 The frame kit is assembled and the side strips are sonically
20 welded together on both sides of the casings. The welded
21 strips and plates form a single continuous metal band around
22 the top and bottom frames that permanently physically retains
23 the assembled kit.

25 I/O Interconnect Options

26 **[0049]** I/O devices may be interconnected with the expansion
27 card via three different embodiments. First, a PC-Card
28 industry-standard Honda-style 15-pin connector may be used
29 with a mating detachable cable. Detachable cables are

1 preferred for light-duty applications where a continuous I/O
2 device connection is neither needed nor desired. Second, a
3 fully integrated fixed cable, having a molded strain relief
4 may be used. Such a fixed cable maintains solid contact in
5 high vibration environments, is protected against lateral
6 stress, and seals out dust. Fixed cables are preferred for
7 dedicated industrial or field applications. Third, at least a
8 portion of the I/O device may be abutted and attached (often
9 via a snap-in-place mechanism) directly to the expansion card,
10 obviating the need for either a detachable or fixed cable.
11 Cableless snap-on I/O devices are preferred for small mostly
12 self-contained I/O devices that permit a compact PDA,
13 expansion-card, I/O-device combination that handles physically
14 as a single piece of equipment. In the instant invention,
15 such snap-on I/O devices must make allowance for the removable
16 memory.

17

18 PDA having Application Specific Card with Removable Media

19 **[0050]** Figure 7 illustrates a PDA **200** equipped with a
20 removable expansion card **100** having both I/O interconnect **140**
21 and removable memory **120** in accordance with the present
22 invention. The application specific circuitry of the
23 expansion card may be used in conjunction with application
24 specific software running on the PDA. This permits the
25 application specific circuitry of the expansion card to make
26 use of the output (e.g., display, sound) and input (e.g.,
27 tablet, buttons, any I/O ports) capabilities of the PDA for
28 user interface functions associated with the specific
29 application. In particular the PDA's display/input-tablet

1 provides for virtual controls and visual indicators for the
2 application. Figure 8 illustrates some of the various types
3 of I/O for which the PDA and removable expansion card of
4 Figure 7 may be equipped. Application-specific functions may
5 include special-function mixed-signal electronics, special-
6 function I/O, special-function data-pumps, and special-
7 function accelerators.

8 9 Application Specific Embodiments

10 11 Generic Removable Media Applications

12 **[0051]** The present invention enables general-purpose
13 portable hosts to perform application-specific functions
14 requiring dedicated ROM. A first large ROM-based application
15 category is that of prerecorded media, such as music, audio,
16 video, and text (for books, newspapers, and other
17 publications). A second large ROM-based application category
18 is customization for programmable devices, such as games,
19 language translators, and other devices having "personality"
20 modules.

21
22 **[0052]** The present invention also enables general-purpose
23 portable hosts to perform application-specific functions
24 requiring non-volatile read/write memory for data-capture,
25 data-logging, data-checkpoints or backups, transaction
26 logging, and data-transport.

27
28 **[0053]** In the illustrated embodiments the non-volatile
29 read/write memory is flash memory in accordance with the

1 standard MultiMediaCard. Such removable flash-memory-based
2 application-specific functions have particular utility to
3 medical and other data acquisition, secure commerce, financial
4 and personal productivity devices making use of unique
5 removable memories for each of multiple individuals, projects,
6 or accounts.

7
8 **[0054]** The removable flash-based memory is also well suited
9 where "sneaker-net" is a viable data transport. Provided
10 manual/user intervention is acceptable, and depending on the
11 speed of data link I/O incorporated into the expansion card,
12 the physical transport of a removable memory device between a
13 PDA-based expansion card and an external system may provide
14 the best solution to fast local transport of large data-sets.
15 For similar reasons, the use of removable memory devices may
16 provide the best solution to rapidly reconfiguring an
17 application-specific expansion card to initiate a large
18 program or use a large data sets. The use of labeled, color-
19 coded, or otherwise distinctive, removable memory devices also
20 may provide the best solution for ease of use for users
21 needing to select a particular program or data set from many
22 for reconfiguring an application specific expansion card.

1 Specific Application Examples

3 Media Player Application

4 **[0055]** The present invention permits a general purpose PDA
5 to be customized (specially adapted) for use as a
6 portable/wearable media player, at the highest-level of
7 functionality not unlike a portable Compact Disk player. Such
8 a player uses the removable memory to store and playback
9 digitally encoded media such as music, audio, or video. In a
10 preferred embodiment the player makes use of the MPEG Layer 3
11 standard for digital audio encoding, generally known as MP3.
12 Another embodiment makes use of the Microsoft Digital Audio
13 standard. Other aspects of a preferred embodiment include an
14 integral AM/FM receiver, a connector for a headset with an
15 integral antenna for the receiver, and an auto-start on insert
16 feature that initiates the media playback upon insertion of
17 the removable memory. The PDA's display/input-tablet provides
18 the virtual controls and visual indicators for the media
19 player.

21 Module For Subscriber Services

22 **[0056]** In accordance with the present invention, an
23 expansion card having I/O and removable memory is inserted
24 into a computer host. The I/O is coupled to a receiver
25 capable of receiving a large number of broadcast messages and
26 services. The removable memory contains subscriber services
27 information for each individual user. The expansion card uses
28 the subscriber services information to filter out messages and
29 services not applicable to the present status of the

1 subscriber. The PDA's display/input-tablet provides the
2 virtual controls and visual indicators for the display and
3 access of captured messages and services.

4
5 Bar-Code Scanning Application (a backup storage example)

6 **[0057]** In accordance with the present invention, an
7 expansion card having I/O and removable memory is inserted
8 into a computer host, a bar-coding peripheral is connected to
9 the I/O portion of the card, and a removable memory card is
10 inserted into the memory slot of the card. After each scan
11 the scanned information is transferred through the I/O
12 connection to the host computer for processing. Additionally,
13 a backup copy of the scanned information is stored on the
14 removable memory. Should the computer host fail or should the
15 operator need to verify scans, the backup can be interrogated
16 with the same or a different host.

17
18 Personal Environmental and Medical Monitoring Devices

19 **[0058]** The present invention permits a general purpose PDA
20 to be customized as a portable/wearable personal environmental
21 monitor. Equipped with the appropriate sensors and
22 application-specific circuitry for sensor signal processing,
23 such a device performs time-stamped data logging of
24 environmental attributes such as ionizing radiation,
25 temperature, and humidity. Similarly, a portable/wearable
26 personal medial monitor data logs health-related attributes
27 such as pulse, temperature, respiration, and blood pressure.
28 The PDA's display/input-tablet provides the virtual controls
29 and visual indicators for the monitoring devices.

1 Automotive and Industrial Diagnostic Monitoring and Control

2 **[0059]** The combined I/O interconnect and removable memory
3 of the present invention also permits a general purpose PDA to
4 be customized (specially adapted) for use as a data logging
5 diagnostic monitor or time-based control device. It is known
6 that the diagnostic connectors of certain vehicles can be
7 adapted to interface with PDAs for real-time monitoring of
8 critical vehicle subsystems. The present invention permits
9 such diagnostic monitoring data to be communicated via the I/O
10 interconnect and logged to the removable memory. Such a tool
11 facilitates tracking subsystem performance over extended
12 periods of time, and permits real-time and deferred graphics
13 of time-varying system performance attributes. The PDA's
14 display/input-tablet provides the virtual controls and visual
15 indicators for the diagnostic monitor.

16
17 Conclusion

18 **[0060]** Although the present invention has been described
19 using particular illustrative embodiments, it will be
20 understood that many variations in construction, arrangement
21 and use are possible within the scope of the invention. For
22 example the number of I/O interconnects, removable memories,
23 contact fingers, number and type of application-specific
24 circuits, and the size, speed, and type of technology used may
25 generally be varied in each component of the invention. The
26 invention is not limited to the standard CompactFlash form
27 factor, but other closed-case removable expansion card form
28 factors are equally applicable. Nor is the invention limited
29 to use of the standard MultiMediaCard, as other types of

1 removable memory or media may also be employed. Functionally
2 equivalent techniques known to those skilled in the art may be
3 employed instead of those illustrated to implement various
4 components. The present invention is thus to be construed as
5 including all possible modification and variations encompassed
6 within the scope of the appended claims.